FocuShift: Actuated Intervention to Prevent Smartphone Overuse via Phone-Attached Shape-Changing Device

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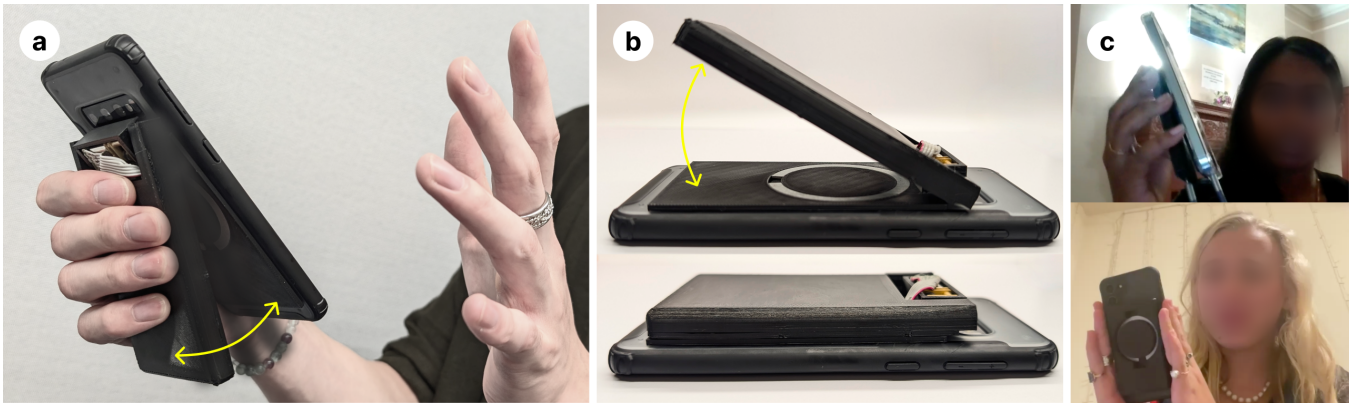


Figure 1: a) FocuShift device that changes its shape, aiming to intervene in smartphone overuse, b) Actuation of FocuShift device that was set to actuate 50 degrees for our study, c) Participants from the study holding the device to describe their experience.

ABSTRACT

With instant gratification constantly available at the tap of a screen, smartphone overuse has quickly become a widespread problem. Many digital applications have been built to combat this issue, either by blocking content entirely or enforcing a mindful pause before entering a distracting app. In this paper, we propose FocuShift, a shape-changing device that attaches to the phone case, as a novel tangible intervention to prevent smartphone overuse. Our device is designed to trigger a shape-change intervention periodically while a user is engaging with a distracting app, altering the ergonomics of the phone and promoting awareness while distracted. We deployed our device in-the-wild for a 48 hour study, comparing screen time between baseline phone usage and phone usage with our shape-changing intervention active. We then conducted interviews with participants to understand the qualitative merits of our proof-of-concept.

CCS CONCEPTS

• **Human-centered computing** → **Interaction devices**.

KEYWORDS

Shape-changing, smartphone distraction, distraction intervention, distraction prevention

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1 INTRODUCTION

In today's attention economy, smartphone apps are designed intentionally to capture and hold the user's focus for as long as possible, providing seamless access to a wide array of distracting content, from video games to social media and more. As a result, many have found themselves deeply addicted to their smartphones. The experience of mindlessly swiping to and entering one's distracting app of choice by muscle memory alone before even realizing it has become extremely commonplace [3], often leaving one little room to exercise any self-control [15]. As a result, commercial and research smartphone apps have been developed to help users combat their overuse habits with demonstrated effectiveness [8, 20]. At the core of many of these methods is the addition of some amount of friction to smartphone use to counteract the seamless nature of typical smartphone engagement. This friction can take the form of outright blocking or delaying consumption of distracting content [8, 11], small inconveniences or delays in the use of an application

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or a smartphone [13], or reflection of usage after distraction to promote mindfulness [9, 19].

While digital solutions have proven effective in various contexts, there remains a budding opportunity to explore solutions that *physically* add friction to digital consumption. Researchers have explored the use of tangible interventions to improve workplace well-being [5]. Sathya et al. [19] utilize the materiality of a receipt to improve screen time reflection on YouTube. Song et al. evaluate a device that requires participants to continuously turn a hand crank to "power" their Twitter usage [21], demonstrating both a reduction in Twitter screen time and a shift toward prioritizing more meaningful content.

Within the realm of physical devices, shape-changing interfaces [17] in particular hold significant potential in the guidance of human behavior. They have been explored as mediums for delivering mobile notifications or opportunities for rich mobile interaction. As part of their exploration of the potential dynamic physical affordances of their shape display, Follmer et al. [7] mention lifting one's phone to direct attention toward notifications or calls as a potential use case. Jang et al. present an integration of a small shape display on the edge of a phone case, with potential applications from haptic notification delivery to tactile input [10]. Other opportunities for dynamic information display or interaction in a mobile, shape-changing format have taken the forms of devices such as actuated curve interfaces [16] or pneumatically actuated soft materials [23]. These rich explorations provide us with a starting point to explore the use of shape change as an intervention for digital well-being.

In this paper, we present FocuShift, a phone-attached proof-of-concept device built as a design probe (Figure 1a), which exhibits a shape change as an intervention during meaningless [14] smartphone use. While digital anti-distraction apps have proven somewhat effective within the bounds of the smartphone screen, we see potential in the exploration of interventions that act instead in the physical world. FocuShift's shape change is capable of altering the ergonomics of smartphone use, making it less comfortable or intuitive to hold the phone and thereby pulling attention away from distracting apps. This added physical inconvenience during engagement with an app nudges [6] the user to actively adjust their activity to the shape change, suggesting an exit from their default state of mindless distraction.

We conducted a 48-hour in-the-wild study in which participants' screen time was tracked for 24 hours with no device and for 24 hours with our device in order to probe the potential of our intervention in preventing smartphone overuse. Preliminary data suggest that our intervention has a significant effect on screen time reduction. Through interviews, we found that participants experienced heightened awareness of usage behaviors and were redirected towards more meaningful activities.

2 DESIGN PROBE

We constructed a design probe (Figure 2) to evaluate the potential of our intervention in-the-wild. As shown in Figure 1a and b, our device is designed to attach to a phone case using a MagSafe [2] connector, allowing us to easily attach our hardware to MagSafe-compatible phone cases. The user first flags the apps they consider "distracting". The shape change is then triggered after the first minute of usage of each distracting app and every ten minutes afterward, decided based on a suggestion from a prior study [22]. Each movement of the device is defined as one opening of the "flap" (shell and components) at a 50° angle (1 second) and one closing of the flap back to the 0° position (1 second) with a 2-second delay in between. Each intervention is defined as 10 of these movements, lasting 40 seconds in total. We chose this movement pattern for its simplicity and repeatability as a baseline proof of concept.

Figure 2 shows the internal components. We use a Seed Studio XIAO nRF52840 Sense [4] as the main micro-controller along with a DRV8833 Dual-Channel H-Bridge to control a single N20 Micro-Metal Gear Motor from Pololu (1000:1), driven by a 3.7V LiPo battery (500 mAh) stepped-up through a 7.5V U3V16F7 Voltage Regulator modulated to output 6.1V. The motor was selected after a series of preliminary experiments to identify the amount of torque required to generate a shape change strong enough to nudge the user away from phone use. We rely on a simple mechanism to generate the shape change in order to maintain robustness in the wild. All parts are 3D printed using PETG for its durability. The entire circuit is built on a custom protoboard and is fully enclosed within the case attachment.

Due to ease of development, we settled on the Android ecosystem for the purpose of this inquiry. We developed a native Android app to trigger the shape change over a BLE connection with FocuShift's XIAO nRF52840. The shape change is initiated when our app sees "overuse" notifications from an app usage tracker [1] that the user installs from the Google Play Store.

3 FIELD DEPLOYMENT

We designed a within-subjects field deployment for 48 hours to test our design probe. We recruited 8 participants (avg. age: 23.875, 5 Female, 3 Male) through local channels and filtered participants to only those who had compatible Android smartphones. Our study was approved by our University's Institutional Review Board (IRB24-1283).

3.1 Study Design

The study aimed to address two primary questions: (1) Does the mere presence of the bulky case impact distracting app usage? and (2) Does the shape change influence distracting app usage? Given the bulky nature of the device, we hypothesize that overall phone usage would naturally decrease due to the less comfortable ergonomics. Beyond this, we seek to determine whether the shape change itself has a significant role in curbing distracting app usage. If the shape change proves to be impactful, it opens up the potential for future, more streamlined designs that seamlessly integrate with the phone's form factor. These designs could specifically target distracting app usage without affecting regular, productive interactions.

3.1.1 Study Procedures. Once participants were recruited, they underwent an onboarding session where we set up the device, demonstrated our app's functionality, chose the distracting apps that required intervention, and asked them to complete the Smartphone Addiction Scale – Short Version (SAS-SV) questionnaire [12]. Each participant experienced two conditions, each over a 24-hour

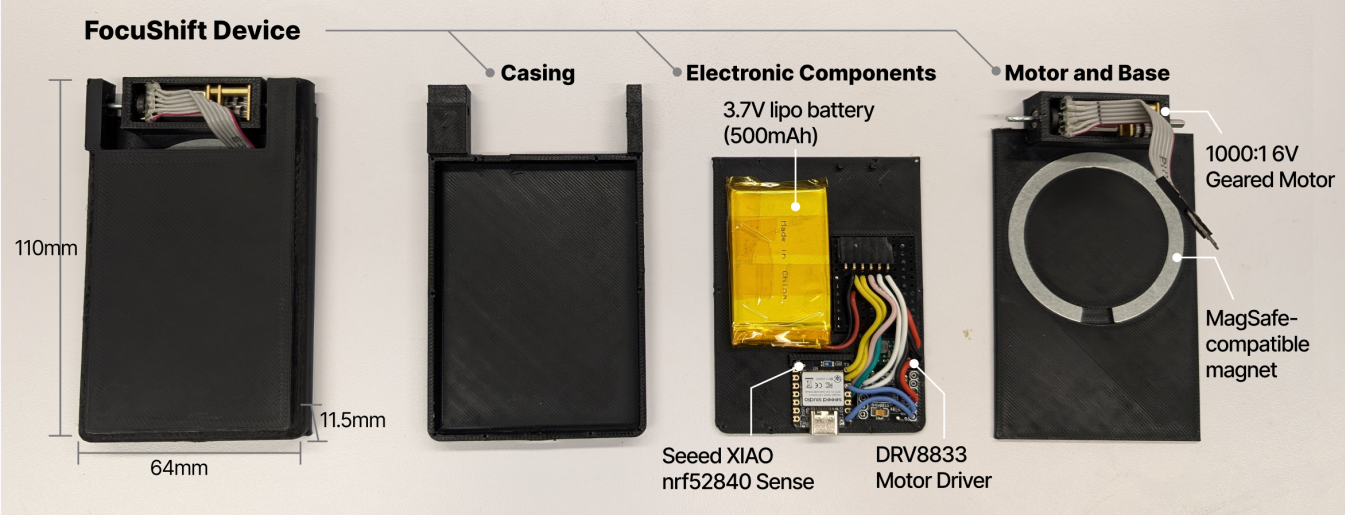


Figure 2: FocuShift device dimensions, and internal components.

Table 1: Participant summary showing the distracting apps picked by each participant along with their SAS-SV score and their study order.

Participant ID	Chosen Distracting Apps	SAS-SV Score	Study Order
P1	Instagram, Facebook, Reddit	22	No Shape Change → Shape Change
P2	Reddit, Instagram, Twitter	39	Shape Change → No Shape Change
P3	Instagram, Facebook, Amazon	27	Shape Change → No Shape Change
P4	Instagram, Youtube	37	Shape Change → No Shape Change
P5	YouTube, FaceBook, Internet Browser	44	Shape Change → No Shape Change
P6	Internet Browser, Messages, WhatsApp	34	No Shape Change → Shape Change
P7	Internet Browswer, Gallery, WhatsApp	40	No Shape Change → Shape Change
P8	Internet Browser, WhatsApp	43	No Shape Change → Shape Change

period: (A) the case installed without shape change (passive 3D-printed block), and (B) the case installed with shape change (FocuShift device). Both the passive block and the device were of the same thickness. The order of these conditions was counterbalanced across our eight subjects to mitigate order effects. Table 1 details the distracting apps chosen, condition orders, and SAS-SV scores for each participant.

We utilize a pre-existing app usage tracker [1] to both track app usage during the study and extract 15 days of pre-study app usage data, giving us a neutral baseline period in which the design probe was not yet installed on participants' phones. Since this baseline data was gathered pre-recruitment, it is free from any potential observation effects.

At the end of each 24-hour period, participants completed a questionnaire specific to the condition they had just experienced. After the full 48-hour testing period, participants took part in a ~60-minute interview where we discussed their questionnaire responses and explored their overall experience through open-ended questions.

3.2 Results

In this section, we discuss the results of our study. We collected a wide range of data in an attempt to understand the effectiveness of our design probe.

3.2.1 Preliminary Quantitative Data Analysis. Although our user study is limited in terms of the number of participants and the duration of the study, the results are promising. While device thickness and possibly the observer effect seemed to reduce overall screen time when compared to pre-study data in condition A, results suggest that shape change, independently of these effects, had a significant effect on screen time and distracting app usage. As shown in Figure 3 (left), there was a 39.7% drop in distracting app usage from condition A to condition B. On average, this represents a 56 minute drop in screen time across participants. Figure 3 (right) details the impact of our shape-changing intervention on both the average total screen time per app and the average session time per app. The average total screen time in condition B was equal to or notably lower than that in condition A for every distracting app involved in our study. On the app session level, it is interesting to note that several distracting apps saw average session time pushed below or to around the 1-minute first intervention trigger mark (e.g., Facebook, X), indicating that either the intervention succeeded

in prompting users to close the app, or users felt the need to close distracting apps quickly to avoid triggering the intervention at all.

3.2.2 Questionnaire Results. The results of the questionnaire (Figure 4) suggest that the shape-change condition was considerably more effective than the non shape-change condition. In the shape-change condition, all participants either agreed or strongly agreed that the shape-change made it difficult to engage with distracting apps. Participants in general had more negative feelings towards the non shape-change condition. The nuances of these results and the possible explanations behind them are discussed in the next section.

3.3 Findings

Through a thematic analysis of interview transcripts, we identified five overarching themes that capture how participants experienced and responded to the shape-changing smartphone intervention: (1) awareness and anticipation of phone use, (2) embodied and physical awareness, (3) social context and accountability, (4) behavioral redirection and adaptation, and (5) design tensions and future potential. Together, these themes illustrate how the device's tangible qualities shaped phone interactions across cognitive, physical, and social dimensions.

3.3.1 Awareness and Anticipation of Phone Use. The intervention heightened participants' awareness of how long they spent on distracting apps and introduced a persistent sense of self-monitoring. The anticipation of the shape change often encouraged participants to limit their engagement before the intervention triggered. P4 explained, *"Whenever I was using the phone, I had in the back of my mind, the time limit of [one] minute. Otherwise, it will [shape change again]."* For some, the device prompted reflection on their own behaviors. P2 shared, *"Sometimes it'd turn on and … I'd be like why am I even here I'm not that interested in [this app]."*

Even when inactive, the *potential* of the device to move acted as a deterrent. P3 described, *"I would consciously just avoid one minute or if I did go to apps, it would be just really quickly,"* while P2 admitted, *"I started to pick it up less because it was just kind of going to be a hassle."* This combination of anticipatory awareness and behavioral restraint positioned the intervention as both a cognitive cue and a deterrent.

3.3.2 Embodied and Physical Awareness. The device's physical presence shaped participants' behaviors in tactile and ergonomic ways. The added thickness and occasional awkwardness of handling made phone interactions more deliberate. P8 explained, *"When I try to put it in my pocket, I have to be really careful,"* while P3 noted that it was *"kind of awkward to scroll."* For some, this physical discomfort directly led to reduced use; P5 reflected, *"My wrist would get tired … so I decided to stop watching."*

Even when not being held, the device's bulk, noise, and altered aesthetics subtly discouraged habitual engagement. P8 reported, *"I found myself reaching for my phone a little less often. Because it's bulkier,"* while P2 remarked, *"I'm not as interested [because] it made my phone less attractive."* Thus, the intervention extended beyond shape-change events, creating an embodied form of mindfulness through its physical affordances.

3.3.3 Social Context and Accountability. Participants' experiences were strongly shaped by the social contexts in which they used their phones. The possibility of the device moving or making noise in public prompted many to preemptively avoid distracting apps. P1 explained, *"I have to explain, oh, I'm doing this experiment from school … I don't want to have to deal with that,"* while P7 described, *"You might be in a public space … and then your phone starts moving and making noise and people start watching you."*

These social pressures encouraged more intentional behaviors and sometimes led to less distracting alternatives. P2 shared, *"I didn't want it to move while I was on the train, so I just listened to music."* Over time, participants also imagined social accountability reinforcing change; as P7 put it, *"If people know that I am trying not to use my phone, I will try not to use my phone [as a result]."*

Together, these accounts highlight how social visibility and interpersonal norms amplified the intervention's behavioral effects.

3.3.4 Behavioral Redirection and Adaptation. When disrupted, participants often redirected their attention toward alternative activities — some productive, others simply different. P1 noted, *"Instead of browsing social media on my phone, I switch to reading the news,"* while P7 shared, *"I usually like to read articles off my phone … so I just read books instead."* Similarly, P3 described shifting work to another device: *"I would definitely just like use [my phone] less and instead just do something else, like go work on my laptop."*

At times, distraction merely migrated to other media. P1 admitted, *"I shifted my usage of the distracting apps to my computer,"* and P2 added, *"I watched a movie."* While such shifts do not necessarily reduce overall distraction, participants often perceived them as healthier or more intentional forms of engagement. The intervention thus facilitated a redirection of attention; sometimes toward productivity, sometimes toward more mindful leisure.

3.3.5 Design Tensions and Future Potential. The experiences above revealed key tensions between awareness, annoyance, and usability. Participants valued the device's ability to physically disrupt distraction but desired greater contextual sensitivity. P1 found it *"particularly bothersome… when I was not using Reddit because I was procrastinating,"* while P2 emphasized that *"there's not a sharp line between productive Instagram usage [like messaging friends and family] and non-productive Instagram usage [like scrolling on Instagram reels]."*

Despite these limitations, participants viewed the shape-changing intervention as more effective than traditional digital reminders. P4 explained, *"The digital thing doesn't work for me… but here it was really restricting me,"* and P5 elaborated, *"With a digital screen time notification, I never once was like, oh, let me just stop using it. But with the shape change… maybe I should stop because it's annoying."*

Participants also envisioned how future iterations could balance disruption and usability. P2 imagined a sleeker, quieter form that could be *"a cute and silly little creature [that tells me] hey get off your phone please,"* while P5 proposed escalation dynamics: *"If it gets progressively worse the more you stay on a distracting app … that would be a game changer."* These suggestions point to the potential of shape-changing interventions as a long-term behavioral tool if refined to align with users' contexts and motivations.

In summary, participants described a multi-layered experience where cognitive awareness, embodied discomfort, social visibility,

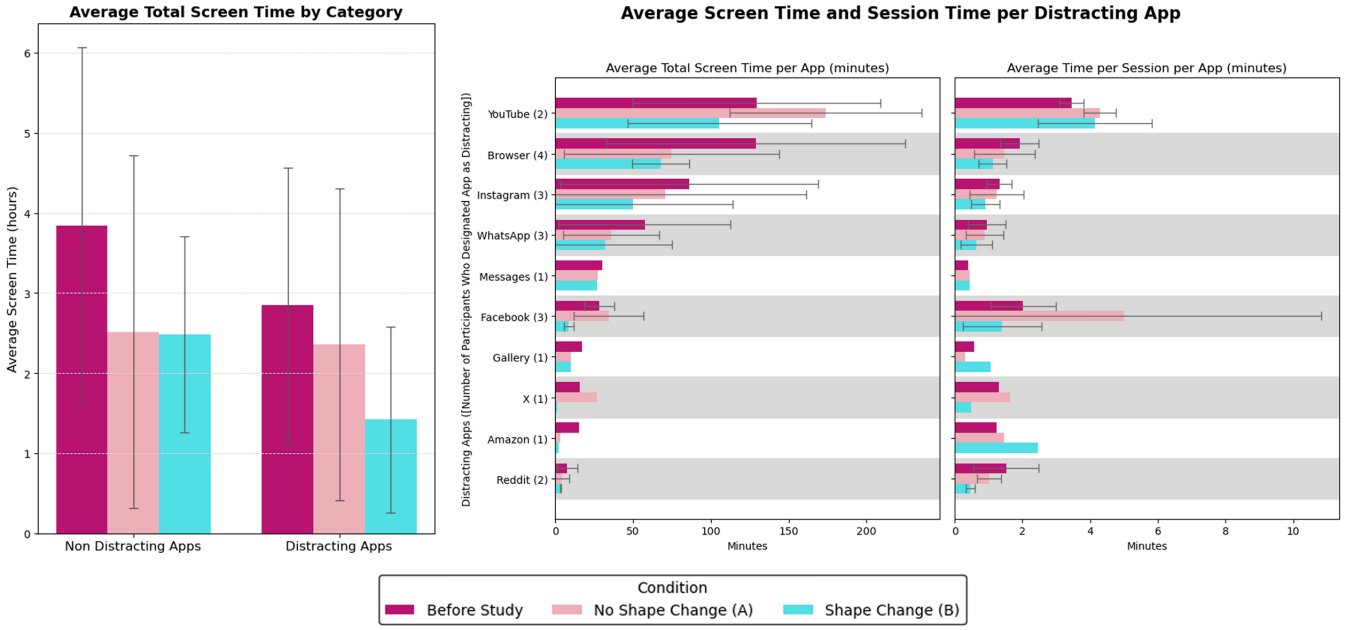


Figure 3: Average screen time across all participants on non-distracting and distracting apps *(left)*, average screen time per app across participants *(middle)*, average session time per app use across participants *(right)*. In the parentheses next to the app names is the number of participants who designated the app as distracting.

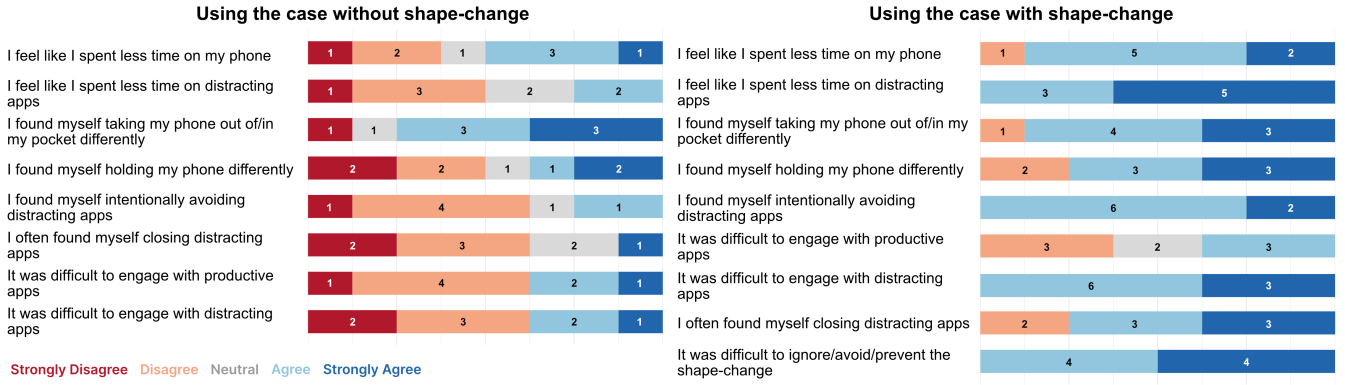


Figure 4: Questionnaire responses

and behavioral redirection worked together to shape how they interacted with their phones. While sometimes inconvenient, the physicality of the intervention provided a form of tangible persuasion that digital notifications alone could not achieve, suggesting that this is a ripe space to promote mindful smartphone usage.

4 DISCUSSION AND FUTURE WORK

We present the implementation and evaluation of a design probe to study an ergonomic intervention against problematic smartphone use. Through a 48 hour in-the-wild study, we found that our shape-changing phone case reduced distracting app usage by 39.7% on average across all participants, resulting in almost 56 minutes less screen time in that period. The broader goal of future studies will be to assess the potential of tangible and shape-changing interventions to promote positive behavior change compared to digital methods. Doing so also provides an opportunity to develop a stronger sense of the design considerations required for long-term, real-world use of a phone-attached shape-changing interface. Although our study is limited, results suggest that further inquiry is warranted, and several natural next directions stand out.

4.1 Longer Study Duration

Our aim with this inquiry was to create a shorter design probe to conduct a preliminary evaluation of our concept. The clearest

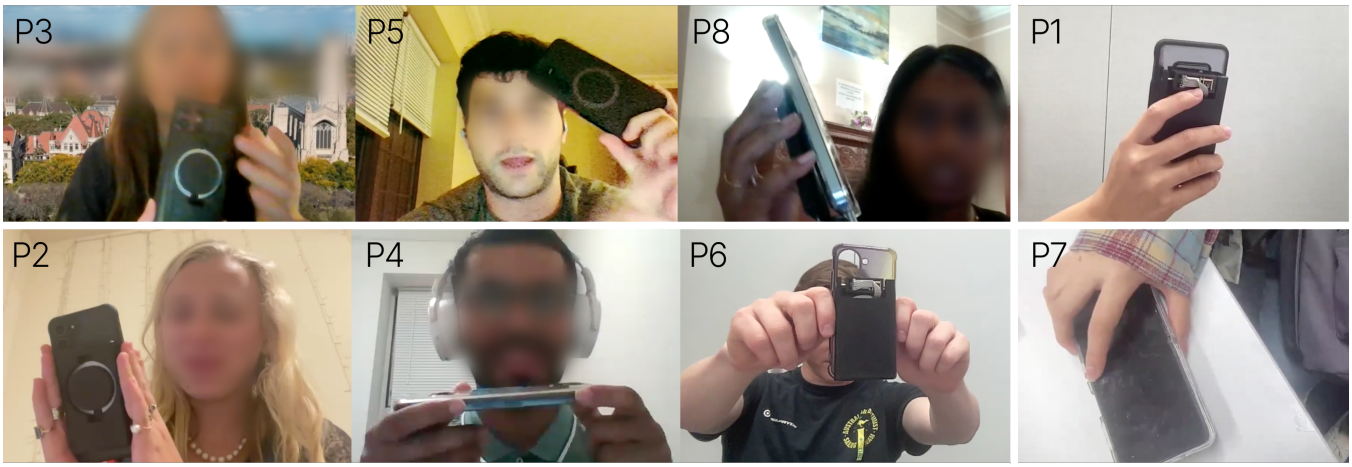


Figure 5: Participants showing how they held the phone when the device actuated. It revealed that they held in different hold types, including 'single-hand avoid HOLD (P3, P5, P8)' 'double-hands avoid HOLD (P2, P4, P6),' 'Keep Holding the Same (P1)' 'Place on a table (P7).'

limitation of this short study is the reliability of the data that can be collected over just 48 hours. Usage patterns can vary widely depending on the day. Over time, participants may adapt both mentally and physically to the device. In addition, smartphone overuse is a "chronic" problem, so it is necessary to explore the feasibility of long-term use of FocuShift. Thus, a 1-2 week user study will be necessary to develop a stronger understanding of the effect of FocuShift's intervention on digital consumption. For such a study, the hardware would need to be streamlined and robust enough to avoid failure.

4.2 More Robust Comparisons

Another pressing next step would be to corroborate the effectiveness of FocuShift's shape-change intervention through comparison against current state-of-the-art digital solutions. Demonstrating an impact on screen time similar to or stronger than that of commercial anti-distraction apps would establish shape change as an intervention modality worth exploring. Purely haptic feedback, such as vibration or electro-tactile stimulation, can also be explored as baseline comparisons.

As suggested by participants, different movement pattern designs for FocuShift can also be investigated, such as one in which shape changes start minimal and become larger, more disruptive, or longer in duration the longer the user ignores the intervention.

4.3 Different Forms of Shape-Change

In this work, we limit our intervention to a simple shape change designed to minimize complications during in-the-wild testing. However, exploring more complex shape-change mechanisms at different resolutions, as done through a self-actuated flexible device in [18] for example, could yield more nuanced outcomes. The relationship between ergonomic conditions and user behavior can be investigated: users might associate certain levels of discomfort with less meaningful phone usage, and, conversely, attach more enjoyable ergonomics to more meaningful digital consumption. Finer resolutions of shape change, for instance micro-textural changes that subtly alter the device without drastically affecting its overall form, could have intriguing effects. These could also lead to more socially acceptable interventions, where the changes are less visible to bystanders. Participants could even be given fine-grained control over the resolution of the shape change, allowing for more personalized experiences.

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